

Descriptive notes on the fauna and flora of Merimbula, Pambula and Back Lakes, New South Wales

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ABSTRACT

An annotated list of animals and plants occurring in the estuarine areas of Merimbula, Pambula and Back Lakes is provided together with information on their abundance and habitat. Notes on the physical environment of these estuarine areas are also given. A brief synopsis of previous studies in the area is given and the distribution of the fauna and flora is compared to other estuarine areas in Eastern Australia.

INTRODUCTION

The few published surveys of New South Wales estuaries have concentrated on the distribution of the major components of the flora and some components of the fauna. The general distribution of mangroves along the New South Wales Coast is reported by Saenger *et al.* (1977) but detailed distributions within an estuary are unavailable for most regions. Areas for which detailed information is available include Towra Point, Botany Bay (Australian Littoral Society, 1977), Sydney region (Blacker, 1977); Fullerton Cove, Hunter River (Hutchings, 1983); Kooragang Island, Hunter River (Moss, in press). Detailed information on the distribution of seagrass beds and mangroves is currently being prepared for each estuary by the New South Wales Division of Fisheries and will be published as technical reports by West *et al.*

Estuarine fauna has in contrast been subjected to a far less co-ordinated approach. Several studies have concentrated on the fauna of restricted areas: Gunnamatta Bay and Cabbage Tree Basin, Port Hacking (Rainer, 1981); Careel Bay, Pittwater (Hutchings and Recher, 1974), Hawkesbury River (Hutchings *et al.* 1977); Gosford Lagoons (Weate and Hutchings, 1979). Recently Hutchings and Murray (in press) have described the polychaete fauna of estuarine areas in New South Wales. Broad scale surveys by the Australian Museum (1977), and CSIRO, Division of Land Use Survey of the South Coast of New South Wales (Anderson *et al.*, 1981) collected some information on the distribution of the larger benthic organisms.

Hutchings and Recher (1982) have tried to collate all the existing data on the fauna of New South Wales mangroves and have compared it to other mangrove areas. Much of this data is anecdotal and often material was not deposited in Museums for later verification. This is critical as in many of the groups considerable taxonomic confusion exists.

Quantitative data on estuarine fauna is lacking. Collett *et al.* (in press) have sampled the fauna of *Posidonia* seagrass beds along the New South Wales coast. Quantitative data is available from Botany Bay (Australian Littoral Society, 1977; State Pollution Control Commission, 1978, 1979a, b, c, 1980, 1981a, b, c; Jones, 1981; Jones and Caddy, 1981). Detailed studies are currently being carried out on the benthos of the Hawkesbury River by Jones of The Australian Museum (in press).

This lack of basic data on the distribution and abundance of estuarine flora and fauna, and the virtual absence of data on life histories, secondary productivity, etc., impose severe constraints on the development and implementation of management plans for estuarine areas in New South Wales. Collett and Hutchings (1977) have shown that many conflicting activities occur within estuarine ecosystems. Management is essential but currently lacking in most estuarine areas.

The purpose of this survey of Merimbula and associated areas was to provide some baseline data on a relatively unmodified south coast estuary and to compare it with other estuarine areas along the east coast. This paper deals only with the distribution of the fauna and flora. A subsequent paper will deal with the seasonal and quantitative aspects of the fauna along the four intertidal transects sampled.

STUDY AREA

Merimbula estuary extends from 36°53' to 36°55'S latitude and 149°52' to 149°55'E longitude (Fig. 1). Merimbula estuary is referred to as Merimbula Lake and covers an area of 5.6 km² and is divided into two by the Princes Highway bridge; Top Lake on the western side and East Lake on the seaward side of the bridge. The catchment, predominantly woodland, covers an area of 42 km² and is drained by Boggy Creek which flows into Merimbula Lake by a delta at the western end.

Mangroves and sedges occur in the delta of Boggy Creek. Seagrass beds (*Posidonia*, *Zostera* and *Halophila*) are found in the eastern half of Top Lake and along the southern shores of East Lake. A maximum depth of 9 m occurs in the centre of Top Lake. Merimbula Lake is permanently open to the sea, but the channel is only 2 m deep and is constricted by a sandspit which encroaches from the south. The estuary is marine with salinities ranging from 26.5-35.5‰ and an annual surface water temperature range of 9-24°C.

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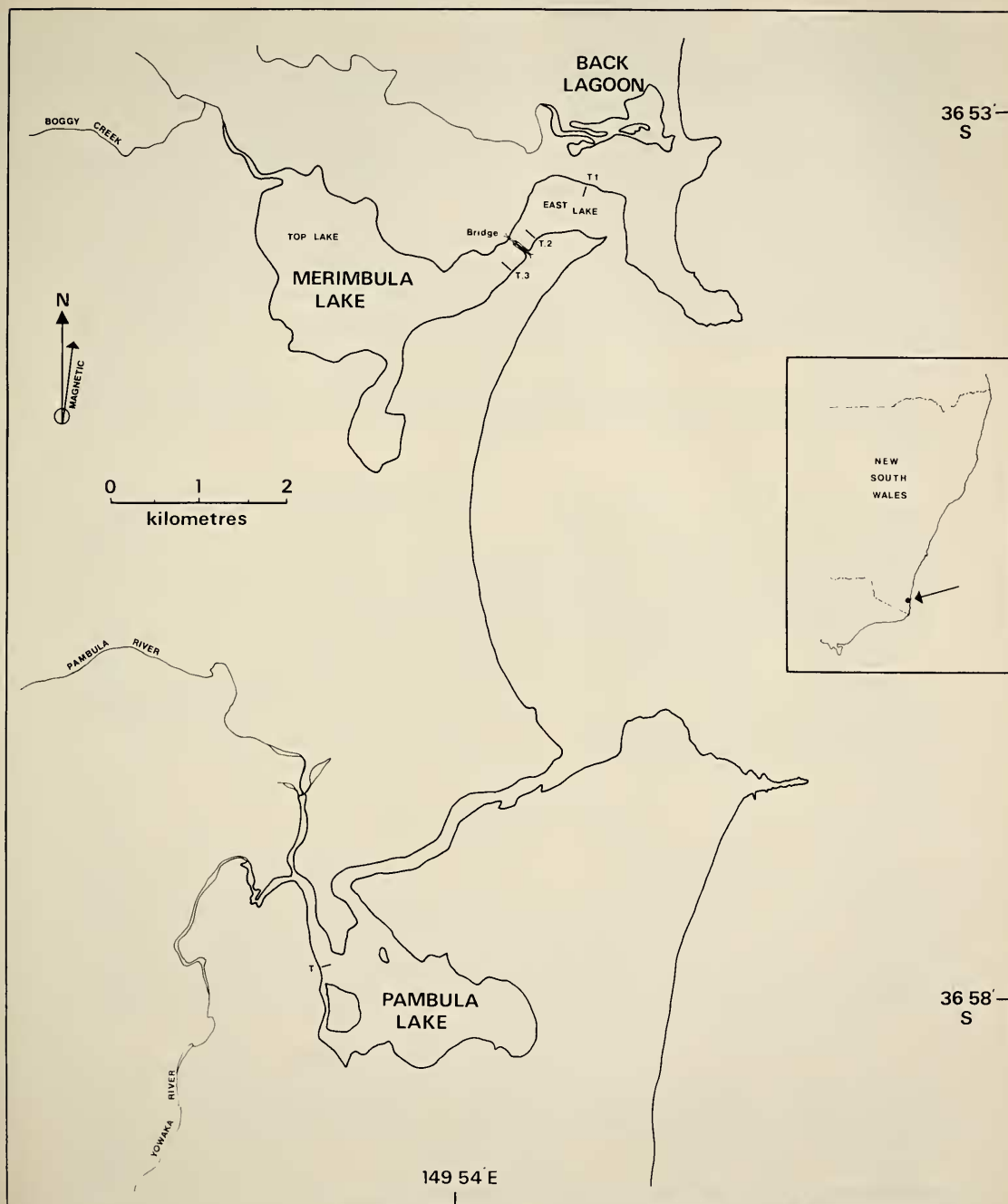


Fig. 1. A map of the study area showing transect sites. T1 Spencer Park, T2 South Bank 200 m seawards of bridge, T3 Top Lake 300 m above the bridge T = Pambula Lake.

Although the main survey was concentrated in Merimbula Lake, we also sampled in nearby Pambula Lake and Back Lake (also known as Back Lagoon). Pambula Lake is 9.6 km south of Merimbula, with a catchment of 270 km². Two rivers drain into the estuary, the Yowaka and the Pambula. River flow in the Yowaka can be fast and the river banks are steep and eroded whereas the Pambula is slow flowing. Both rivers flow into Saltwater Creek before entering Pambula Lake. The lake is about 3 km² in area, 100-200 m wide and up to 3 m deep, with many sandy shoals and rocky outcrops. It is permanently open to the sea. The salinity in the lake is usually above 30‰, but Saltwater Creek has a more varied salinity(depending on the rainfall) from 0-28.7‰ often with layering. Extensive *Zostera* beds, and a mangrove island of *Avicennia* with patches of salt marsh, occur in the lake.

Back Lake lies just north of Merimbula and is fed by a small stream draining a catchment of 33 km². The stream flows through marshes before entering the western end of Back Lake.

The lake is about 0.3 km² in area. It is normally closed to the sea, but after heavy rain the lake rises rapidly and the entrance is bulldozed to prevent flooding of surrounding farmland. When open to the sea, the spring tidal range within the lake is about 1 m. The western margins of the lake are muddy with *Juncus* and other sedges along the waterline. Patches of *Zostera* occur near the seaward entrance on muddy sand, but the entrance is clean sand.

During the study period, Back Lake was open during July, 1975, but then closed for 5-6 months until being opened again artificially in early March, 1976. When the lake is closed to the sea the salinity falls and the water level stabilizes above the tidal high water mark.

SAMPLING METHODS

Sampling was carried out at 3 monthly intervals from July, 1975 to March, 1976. Three intertidal transects were surveyed in Merimbula Lake (Fig. 1): T.1 Spencer Park, 0.6 km from the mouth, T.2 South bank, 200 m seaward of bridge and T.3 Top Lake, 300 m above the bridge. The transects were chosen as being representative of the intertidal environments in the lake. At each of the four to six stations on each transect, two cores of 0.11 m² area and 0.25 m depth were collected and sieved through a 1 mm mesh screen.

Subtidal fauna was sampled qualitatively using SCUBA and by a Smith-McIntyre grab along the main channel of East Lake and in the *Posidonia* and *Zostera* seagrass beds along the southern shores of East Lake. Qualitative plankton trawls were taken underneath the Princes Highway Bridge at each sampling period. The pelagic fauna was sampled qualitatively by pulling nets of varying mesh sizes through the *Posidonia* and *Zostera* seagrass beds along the southern shores of East Lake. Qualitative collections were also made in the mangroves and

salt marshes in the southern area of Top Lake west of the airstrip, in the salt marshes at the entrance of Boggy Creek and along the rocky shores at the seaward end of East Lake.

Sediment samples were collected from each station on the transects and at various points along the estuary.

In Pambula Lake, quantitative intertidal collections were made across a sand bank as indicated in Fig. 1, and qualitative sampling was carried out in several habitats including rocky intertidal areas at the seaward entrance to the Lake, *Zostera* seagrass beds, *Avicennia* mangroves and the salt marsh communities. In Back Lake, all sampling was qualitative and the following habitats were sampled; intertidal beaches both of clean sand and muddy sand, *Zostera* seagrass beds, and salt marsh and sedge communities at the head of the estuary.

Material has been deposited in The Australian Museum.

RESULTS

A. SEDIMENT CHARACTERISTICS

Top Lake

The silt content (0.1%) and the median particle size of sand ($Md = 0.35$ mm) are fairly constant throughout the lake, however the proportion of organic carbon increases from the shoreline to the deepest areas where it reaches 7.3%. Dead bivalve shells are common in the deeper areas. The exit channel from the bridge is clean sand ($Md = 0.30$ mm) with patches of gravel.

Merimbula Lake Region

The channel bed in East Lake consisted of loose stones, broken shells and a mixture of coarse and medium sand, median grain size (Md) values range from 0.53-2.98 mm, sorting coefficient (QDg) values from 0.15-0.39 and skewness (Sk) values of 1.06 or greater. Silt was absent and organic carbon averaged 0.1%. The sediment among the *Zostera* and *Posidonia* beds was medium sand ($Md = 0.34$ mm) with little silt.

Sediments in the three transects were as follows:

T.1 — Medium sand, marine in origin ($Md = 0.35$ -0.4 mm) with stones and gravel from the embankment at high water mark. Silt (1.6%) and organic carbon (1.3%) accumulate in the depression in the lower part of the transect.

T.2 — Medium to fine sand ($Md = 0.28$ -0.30 mm) with little silt (0-0.2%) and an accumulation of organic carbon at the low water mark (1.3%).

T.3 — Ranges from clean medium sand ($Md = 0.34$ mm) at high water mark to mud ($Md = 0.30$ mm, 1.1% silt and 0.4% organic carbon) at low water mark.

The sediments are sharply delineated into marine deposits on the shallow banks which extend to the middle of Top Lake and the fluvial deposits extending

from the deep part of Top Lake to Boggy Creek. The marine deposits are characterised by very little silt, or organic carbon, but relatively large amounts of calcium carbonate, up to 2.22%. Fluvial deposits in comparison contain more silt and organic carbon with the highest concentration (7.3%) occurring in the deeps of Top Lake and very low levels (0.07%) of calcium carbonate.

B. FLORA

On the foreshores of Merimbula Lake, the following salt marsh plants occur: *Sporobolus virginicus*, *Juncus kraussii*, *Spergularia rubra* and *Selliera radicans*. *Triglochin striata* occurs in seepage areas. Dense stands of *Sarcocornia quinqueflora* occur at neap high tide in some places. Dense patches of shrub-like *Avicennia marina* less than 4 m high occur, sometimes forming thickets 20 m in depth. At the mouth of Boggy Creek, the mangroves form denser stands and trees reach a maximum height of 5 m. *Avicennia* is abundant, and *Aegiceras corniculatum* common. The salt marsh is well developed with tall stands of sedge *Scirpus "maritimus"* on the saline mudflats, and *Typha* sp. and *Phragmites australis* occur higher up the creek.

The algae *Enteromorpha* and *Ulva* are common from low to mid water mark throughout the estuary. Other species such as *Cladophora* sp., *Hormosira banksii*, *Codium* sp. and *Lophosiphonia* sp. occur on oyster racks, and along the channel. *Codium* sp. and *Sargassum* sp. are abundant on boulders below low tide. Fine filamentous algae occur as epiphytes on the sea grasses, but these were not identified. Extensive beds of seagrasses occur throughout the estuary except for the channel and the deeper parts (5-9 m) of Top Lake. Intertidally and down to extreme low water spring, *Zostera capricorni* and *Z. muelleri* occur with *Z. capricorni* being dominant. Below the *Zostera*, *Posidonia australis* occurs to 3-4 m. Interspersed with *Zostera* and *Posidonia*, is *Halophila ovalis*.

C. FAUNA

Tables 1, 2 and 3 provide annotated lists of the fauna and flora of Merimbula, Back Lake and Pambula Lake together with an indication of the abundance.

An extensive quantitative sampling program of the benthos of the *Posidonia* seagrass beds in East and Top Lake was carried out as part of a survey of the benthos of *Posidonia* along the New South Wales coast. An analysis of the results including a species list is given by Collett *et al.*, (in press).

DESCRIPTIVE NOTES ON FAUNA AND FLORA

TABLE 1. Annotated list of aquatic macrophytes and invertebrate animals recorded in Merimbula, Pambula and Back Lake estuaries. Species marked with an asterisk were found in quantitative samples from intertidal muddy sand or in 0.1 m² cores from subtidal sea grass beds. Relative abundance in this list is shown by P — rare or doubtful; F — fairly common; C — common; A — abundant; N — numerous records.

Species	Nos. recorded	Merimbula	Back Lake	Pambula estuary	Remarks			
	1	2	3	4	5	6	7	8
		Intertidal sandy mud	Rocks and oyster racks	Salt marshes and mangroves	Subtidal			
ALGAE								
<i>Acetabularia</i> sp.	1			P				
<i>Cladophora</i> sp.	10		C			C	C	
<i>Codium</i> sp. (arborescent)	4				P			
<i>Codium</i> sp.	N				C			
<i>Codium</i> sp. (prostrate)	2	P						
<i>Enteromorpha</i> sp.	10		A		A	A	A	
<i>Colpomenia sinuosa</i> (epiphytic)	4				C			on <i>Zostera</i>
<i>Dictyota</i> sp.	4				C			on <i>Posidonia</i>
<i>Hormosira banksii</i>	10		A					
<i>Sargassum</i> sp.	5				F			
<i>Laurencia</i> sp.	6				C			on <i>Zostera</i> and <i>Posidonia</i>
<i>Lophosiphonia</i> sp.	N				C			
<i>Polysiphonia</i> sp.	3				F			on <i>Posidonia</i>
nr. <i>Thuretia</i> sp.					P			
<i>Ulva</i> sp.	10		A		A			
ANGIOSPERMS								
<i>Aegiceras corniculatum</i>	1			F				in Boggy Creek
<i>Avicennia marina</i>	10			A			A	
<i>Cotula coronopifolia</i>	1					P		
<i>Halophila ovalis</i>	15	A			A			
<i>Juncus kraussi</i>	6				A	A	A	
<i>Phragmites australis</i>	2			A			A	
<i>Posidonia australis</i>	15				A		P	
<i>Sarcocornia quinqueflora</i>	5			A		C	P	
<i>Sarcocornia</i> (bushy) (= <i>Arthrocnemum</i>)	3				C	C		
? <i>Scirpus maritimus</i>	2				P			
<i>Selliera radicans</i>	1				P			
<i>Spergularia rubra</i>	1				F			
<i>Sporobolus virginicus</i>	6	C			C	A	A	
<i>Triglochin striata</i>	2				F		F	
<i>Typha</i> sp.	2				P			low salinity to FW.
<i>Zostera capricorni</i>	15	A				A	A	
<i>Zostera muelleri</i>	2	?C			?		?	not distinguished in field

Species	Nos. recorded	Merimbula	Back Lake	Pambula estuary	Remarks			
	1	2	3	4	5	6	7	8
PORIFERA	4							
CNIDARIA								
Actinia ?tenebrosa	5		P				F	
?Hydractinia	5				F			on Nassarius jonasii
?Edwardsiidae*	15	P			P			
PLATYHELMINTHES:								
TURBELLARIA	6							
NEMERTINA	31						1	
PHORONIDA								
Phoronis albomaculata*	11	F			F			
Phoronis psammophila*	8	F			P			
Phoronopsis harmeri*	12	C			F			
SIPUNCULA								
Phascolosoma annulatum*	6	P			P			
POLYCHAETA: ERRANTIA								
Ancistrosyllis cf. constricta	2	P			P			
Australonereis ehlersi*	12	A				C	P	
Brania clavata*	1	P						
Ceratonereis								
pseudoerythraeensis*	18	A			C	P	F	
Ceratonereis mirabilis*	11	C			F			
Eulalia (Eumida) sanguinea*	4	P						
Eunice antennata*	2	P			P			
Exogone cf. verugera*	1	P						
Glycera americana*	3	P			P			
Glycera tessellata*	2	P			P			
Harmothoe praeclara*	28	C			C			on Zostera
Lumbrineris coccinea*	2	P				P		
Lumbrineris latreilli*	30	C			A			
Lumbrineris tetraura*	9	P			F			
Lysidice natalensis*	1		P					
Marphysa macintoshi*	1			P				
Marphysa sanguinea*	2	P			P			
Nematonereis unicornis*	1	P						
Nephtys australiensis*	115	A			C	C	A	
Nephtys longipes*	9	F						
Nereis (Neanthes) acuminata	1				P			
Nereis (Neanthes) vaalii*	5		P					
Ophiodromus sp. 1*	10	P			P			
Paralepidonotus ampulliferus	1		P					
Perinereis nuntia								
brevicirris*	6	F				P	P	under stones
Perinereis obfuscata*	2	P						

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Species	Merimbula				Back Lake	Pambula estuary	Remarks
	Nos. recorded	Intertidal sandy mud	Rocks and oyster racks	Salt marshes and mangroves	Subtidal		
	1	2	3	4	5	6	7
							8
<i>Phyllodoce (Anaitides)</i>							
<i>?australis*</i>	12	P			P	P	P
<i>Pionosyllis ehlersiaeformis*</i>	1				P		
<i>Platynereis australis*</i>	2	P					
<i>Platynereis dumerilii*</i>	3				P		on <i>Zostera</i>
<i>Progoniades</i> sp. 1	1						P
<i>Protodorvillea</i> sp. 1*	1	P					
<i>Pseudonereis variegata</i>	1		P				
<i>Schistomeringos rudolphi*</i>	6	P			P		
<i>Sigalion ovigerum*</i>	20	F				P	P
<i>Sphaerosyllis semiverrucosa*</i>	1	P					
<i>Syllis (Typosyllis) armillaris*</i>	2	P			P		
<i>Syllis (Typosyllis) hyalina*</i>	2	P					
POLYCHAETA: SEDENTARIA							
<i>Aonides oxycephala*</i>	5	P			P		
<i>Armandia intermedia*</i>	18	F			F		
<i>Barantolla lepte*</i>	49	C			C	P	P
<i>Boccardia chilensis</i>	4		P			P	P
<i>Capitella capitata*</i>	4	P			P		
<i>Caulleriella tricapitata*</i>	1	P					
<i>Chaetopterus variopedatus</i>	1	P					
<i>Cirriiformia chrysoderma nuchalis*</i>	9	F			P		
<i>Cirriiformia filigera*</i>	22	A					
<i>Cirriiformia tentaculata*</i>	39	F			A		
<i>Euclymene trinalis*</i>	1	P					
<i>Ficopomatus enigmaticus</i>	1						F
<i>Galeolaria caespitosa</i>	8		A				A+
<i>Heteromastus filiiformis*</i>	15	F			F		
<i>Janua (Dexiospira) brasiliensis</i>	6				A		
<i>Janua (Dexiospira) steueri</i>	1			A			
<i>Magelona cf. pitelkai*</i>	13	P			F	P	
<i>Mediomastus californiensis*</i>	21	C			C		
<i>Mesochaetopterus ?sagittarius*</i>	1				P		
<i>Terebella</i> sp. nov.*	14	F	P				
<i>Notomastus torquatus*</i>	10	F		P	P	P	P
<i>Owenia fusiformis*</i>	26	F		P			F
<i>Phylo felix</i>	1				P		
<i>Pista typha*</i>	33	C			C		
<i>Polydora socialis*</i>	13	F					
<i>Polyoplthalmus pictus*</i>	2	P					
<i>Pomatoceros caeruleus</i>	3		P		P		
<i>Prionospio (Aquilaspio) aucklandica*</i>	9	P			C		
<i>Prionospio (Aquilaspio) multipinnulata*</i>	3				P		

Species	Merimbula					Back Lake	Pambula estuary	Remarks
	Nos. recorded	Intertidal sandy mud	Rocks and oyster racks	Salt marshes and mangroves	Subtidal			
	1	2	3	4	5	6	7	8
<i>Prionospio (Minuspio) cirrifera</i> *	9	P			P			
<i>Pseudopolydora kemp</i> i	15	C					P	
<i>Rhinothelopus macer</i>	1				P			
<i>Samythella</i> sp.*	1	P						
<i>Scoloplos cylindrifera</i> *	1	P						
<i>Scoloplos simplex</i> *	27	C				C	P	
<i>Spio pacifica</i> *	2	P						
<i>Terebella</i> cf. <i>ehrenbergi</i> *	3	P	P					
CIRRIPEDIA								
<i>Balanus amphitrite</i>	2					P	P	
<i>Balanus variegatus</i> var. <i>cirratus</i>	1		P					
<i>Balanus trigonus</i>	1		P					
<i>Chthamalus antennatus</i>	4		P				P	
<i>Elminius modestus</i>	12		A			A	A	
<i>Tetracitella purpurascens</i>	1		F					
AMPHIPODA								
(incompletely identified)								MER No. is reference specimen
<i>Aora</i> MER 312 H	1				P			
? <i>Aoroides</i> * MER 148 Y	6	P			P			
<i>Atylus</i> MER 305 E	1						P	
? <i>Corophium</i> * MER 93 K	5	P			P			
<i>Cymadusa</i> sp. 1* MER 93 J	43	C			A		C	in sea grasses
<i>Cymadusa</i> sp. 2* MER 275 Y	9				C		P	in sea grasses
<i>Exoedicerus fossor</i> *	75	A				P	F	intertidal
<i>Exoedicerus</i> sp.* MER 56 C	1	P						
Eusiridae ? gen MER 301 J	2				P			
Haustoriidae gen. M*								
MER 3 D	9	F						
Haustoriidae gen. N.								
MER 163 D	1	P						
Isacidae* MER 249 E	3	P						
<i>Limnoporeia yarragae</i> *	1	P						
<i>Maera</i> sp. MER 289 L	1				P			
? <i>Megamphopus</i> * MER 93 P	12	P			P			in <i>Zostera</i>
<i>Melita</i> sp. * MER 42 D	17	P			P	P	P	in <i>Zostera</i>
? <i>Monoculodes</i> * MER 195 N	12	C						in <i>Zostera</i>
Oedicerotidae sp. A*								
MER 207 K	5	F						
Oedicerotidae sp. C*								
MER 220 Z	5	F						
Oedicerotidae sp. 1								
MER 275 O	1	P			P			
Oedicerotidae sp. 2*								
MER 279 D	3		P					
<i>Orchestia chilensis</i> MER 5 A	2	P						drift weeds at HWS

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		Intertidal sandy mud	Rocks and oyster racks	Salt marshes and mangroves	Subtidal			
<i>Orchestia</i> sp. MER 96 E	8	P				C	P	at HWS
<i>Paracalliope</i> sp.* MER 24 D	7	P			P			in weed beds
Phoxecephalidae A*								
MER 241 C	46	A			A		P	in <i>Zostera</i>
Phoxecephalidae B*								
MER 275 P	31	A						in <i>Zostera</i>
? <i>Podoceropsis</i> sp.*								
MER 73 F	2	P			P			
? <i>Talitroides</i> MER 172 A	1	P						HW drift weed
<i>Talorchestia</i> sp. MER 308 B	5	F						HW drift weed
<i>Tethygeneia</i> sp.	1	P						in <i>Zostera</i>
<i>Urohaustorius metungi</i> *	24	A					P	
<i>Victoriopisa</i> sp.	1						P	
ISOPODA								
<i>Actaccia pallida</i> *	88	A				F	F	sand at HW
<i>Ancinus</i> sp. MER 307 D	2						F	in low salinity
<i>Cirolana</i> cf. <i>arcuata</i> *	68	A					F	
<i>Deto marina</i>	2			P			P	
<i>Exosphaeroma laevis</i>	2					P	P	on rock near mouth
<i>Cymodoce</i> sp. MER 307 C	2						P	in low salinity
<i>Codonophilus</i> cf.								
<i>imbricatus</i>	1				P			fish parasite
<i>Ligia australiensis</i>	1			P				on log
<i>Mesanthura</i> sp.* MER 272 Q	1	P						
<i>Nerocila macleayi</i>	1				P			fish parasite
<i>Paridotea unguolata</i>	4	P			P			on <i>Zostera</i>
<i>Sphaeroma quoyanum</i>	1						P	on rotten log
Sphaeromatidae ? gen.								
MER 304 D	5						C	in low salinity
TANAIDACEA								
	4							
CUMACEA								
	5							
LEPTOSTRACA								
	6							
MYSIDACEA								
<i>Gastrosaccus dakini</i> *	6	P					P	weed beds and plankton
DECAPODA: MACRURA								
<i>Alpheus</i> sp.*	31	F			F	P	P	<i>Zostera</i> beds
<i>Macrobrachium intermedium</i>	20				A		A	netted in <i>Zostera</i> beds
<i>Palaemon affinis</i>	1				P			netted in <i>Zostera</i> beds
<i>Penaeus plebejus</i> (juveniles)	22	P			P		P	in <i>Zostera</i> beds

Species	Nos. recorded	Merimbula	Back Lake	Pambula estuary	Remarks			
	1	2	3	4	5	6	7	8
	Intertidal	sandy mud	Rocks and oyster racks	Salt marshes and mangroves	Subtidal			
<i>DECAPODA ANOMURA</i>								
<i>Callianassa arenosa</i> *	12	F			P	A	P	in mud
<i>Callianassa australiensis</i>	6	F				P	C	in sand
<i>Diogenes custos</i> *	5	F						
<i>DECAPODA BRACHYURA</i>								
<i>Australoplax tridentata</i>	4						A	mangrove mud
<i>Brachynotus spinosus</i> *	2	P	P					
<i>Carcinus ?maenas</i> *	6	P			P			
<i>Cyclograpsus audouinii</i>	2		P					
<i>Halicarcinus cf. ovatus</i> *	14	P			P		P	
<i>Halicarcinus paralacustris</i>	17	F			P		P	
<i>Heloeccius cordiformis</i>	4			F			F	
<i>Helograpsus haswellianus</i>	4			C			C	
<i>Macrophthalmus latifrons</i>	1					P		
<i>Macrophthalmus setosus</i>							P	
<i>Macrophthalmus tasmanica</i>						P		
<i>Mictyris longicarpus</i> *	60	A					F	
<i>Mictyris platycheles</i> *	62	A				?	P	
<i>Ovalipes australiensis</i>	1				P			moribund
<i>Pachygrapsus laevis</i>	2		P					
<i>Paragrapsus laevis</i> *	8	P				F	P	
<i>Pilumnopus serratifrons</i>	11		P			P		
<i>Portunus pelagicus</i>	6				P			netted
<i>Sesarma erythrodactyla</i>	5			C			A	
<i>Thalamita intermedia</i>	1	P						in <i>Zostera</i>
<i>Thalamita sima</i> *	4				P			
<i>MOLLUSCA: POLYPLACOPHORA</i>								
<i>Ischnochiton elongatus</i>					P			
<i>crispus</i>	1							on stones
<i>BIVALVIA</i>								
<i>Ambuscintilla praemium</i> *	7	P						
<i>Anadara trapezia</i> *	21	P			C			
<i>Arthritica helmsi</i> *	57	A			P	A	F	
<i>Bankia cf. carinata</i>	2			C				in rotten logs
<i>Cyammimactra cf. symmetrica</i> *	2				P			
<i>Eumarcia fumigata</i> *	50	C				P	P	
<i>Fluviolanatus amarus</i> *	3	P					P	
<i>Glaucomomya plankta</i>	1						P	mangrove mud
<i>Irus crenata</i> *	1	P						
<i>Katelysia rhytiphora</i> *	6	P			P			in <i>Zostera</i> beds
<i>Katelysia scalarina</i>	1	P						
<i>Lasaea australis</i>	3		P				C	among <i>Galeolaria</i> tubes at mouth
<i>Laternula creccina</i> *	11	P			P			in weed beds
<i>Mesodesma elongata</i> *	8	P					P	
<i>Musculus cumingianus</i>	1		P					

DESCRIPTIVE NOTES ON FAUNA AND FLORA

Species	Nos. recorded	Merimbula	Back Lake	Pambula estuary	Remarks			
	1	2	3	4	5	6	7	8
<i>Mysella</i> sp.*	48	C			C		F	
<i>Mytilus edulis</i>	4		P		F		P	
<i>Notospisula trigonella</i> *	5	P			P			
<i>Ostrea angasi</i>	1		P					
<i>Psammobia donacioides</i> *	8	P			P	C		
<i>Saccostrea commercialis</i>	12		A			A-P*	A	+90% dead in March
<i>Solemya velesiana</i> *	2				P			
<i>Tapes</i> cf. <i>watlingi</i> *	1	P						
<i>Tellina</i> (<i>Abranda</i>) <i>hypelliptica</i>	1				P			
<i>Tellina</i> (<i>Abranda</i>) <i>modestina</i> *	1				P			
<i>Tellina</i> (<i>Macomona</i>) <i>deltoidalis</i> *	34	C			C	P	C	
<i>Trichomya hirsuta</i>	8		P		C			on rock or gravel
<i>Wallucina assimilis</i> *	23	C			C			
<i>Xenostrobus secuiis</i>	8		F			P	C	
GASTROPODA: PROSOBRANCHIA								
<i>Assimineia tasmanica</i>	2					P	F	in low salinity
<i>Austrocochlea constricta</i> *	38	P	C		F	F	P	
<i>Bedeva hanleyi</i> *	21	P			F			
<i>Bembicium auratum</i>	9		A			A	P	
<i>Bembicium melanostomum</i>	1		P					near mouth
<i>Bembicium nanum</i>	7		C	A		C	C	
<i>Bittium lacertinum</i> *	10	P			A			sea grass beds
<i>Patelloida mimula</i>	15		F			P	F	on oysters
<i>Cominella eburnea</i>	1		P					near mouth
<i>Diala</i> sp. * MER 51 J	18	F			A			on <i>Zostera</i>
<i>Hinea braziliiana</i>	1						P	rock near mouth
<i>Hydrobia buccinoides</i>	3	P			A	A		low salinity
<i>Littorina scabra</i>	4			P			P	on mangroves
<i>Littorina unifasciata</i>	5		C				C	
<i>Melosidula zonata</i>	1						P	on mangroves
<i>Montfortula conoidea</i>	2		P					
<i>Morula marginalba</i>	2						P	rocks near mouth
<i>Nassarius burchardi</i> *	42	F			C	C	P	
<i>Nassarius jonassii</i> *	50	C			F	C	F	
<i>Nerita atramentosa</i>	8		F			F		
<i>Neritina</i> sp.* MER 283 K	2	P						sea grass beds
<i>Nodolittorina pyramidalis</i>	1		P					rock at mouth
<i>Patelloida alticostata</i>	1		P					
<i>Polinices</i> (<i>Conuber</i>) <i>sordidus</i> *	17	F					P	
<i>Prothalotia comtessei</i> *	18	P			F			on <i>Zostera</i>
<i>Pseudoliotia micans</i> *	10	F			P		P	on <i>Zostera</i>
<i>Pyrazus ebeninus</i> *	25	C				C	A	
<i>Tatea kesteveni</i>	4			P			A	in low salinity
<i>Tatea rufilabris</i>	1	P						
<i>Velacumantis australis</i> *	5	P				P	P	

Species	Merimbula					Back Lake	Pambula estuary	Remarks
	Nos. recorded	Intertidal sandy mud	Rocks and oyster racks	Salt marshes and mangroves	Subtidal			
	1	2	3	4	5	6	7	8
<i>GASTROPODA: OPISTHOBRANCHIA</i>								
<i>Akera soluta</i> *	15	F						
<i>Aplysia</i> cf. <i>dactylomela</i> (juv.)	1	P						
<i>Chemnitzia</i> sp. MER 220 M	1	P						
<i>Cingulina spina</i> *	13	P			F			
<i>Odostomia</i> sp. MER 219 X	1	P						
<i>GASTROPODA: NUDIBRANCHIA</i>								
" <i>Aclis</i> " MER 51 L, 58 P	2	P						in <i>Zostera</i>
<i>GASTROPODA: PULMONATA</i>								
<i>Ellisiphon</i> cf. <i>denticulatus</i>	3		P					
<i>Ophiocardelus quoyi</i>	8				F		P	
<i>Ophiocardelus sulcatus</i>	1						P	
<i>Onchidella patelloide</i>	2	P						
<i>Salinator fragilis</i> *	3	P						
<i>Salinator solida</i>	4			A		F	A	
<i>Siphonaria</i> cf. <i>diemenensis</i>	1		P					
<i>CEPHALOPODA</i>								
<i>Euprymna stenodactyla</i>	1				P			in <i>Zostera</i>
<i>Idiosepius notoides</i>	1				P			in <i>Zostera</i>
<i>ECHINODERMATA</i>								
<i>Patiriella exigua</i>	2		P					
<i>Amphipholis squamata</i>	3	P			P			
<i>Leptosynapta dolabrifera</i> *	10	P			P			
Synaptidae ?gen. MER 285 T	2				P			
<i>CHORDATA: ASCIDIACEA</i>								
	8		P					

NOTE: Nr. means close to this genus, may represent an undescribed genus.
 cf. means close to that species, but not that species, again may represent an
 undescribed species? Implies identification of genus or species is doubtful.

DESCRIPTIVE NOTES ON FAUNA AND FLORA

TABLE 2. List of fish (Chordata: Pisces) recorded in Merimbula and Pambula estuaries.

Scientific and common name	Number of records	Merimbula	Pambula	and Remarks Total caught
<i>Acantholeuteres spilomelanurus</i> — leather jacket	3	P		9
<i>Acanthopagrus australis</i> — yellow fin bream	1	P		1
<i>Acanthopagrus butcheri</i> — black bream	1	P		4
<i>Aldrichetta forsteri</i> — yellow-eyed mullet	2	P		27
<i>Ammotretis rostratus</i> — flounder	5	P		13
<i>Arenigobius bifrenatus</i> — goby	2	P		2
<i>Argyrosomus hololepidotus</i> — mullet	1	P		1
<i>Centropogon australis</i> — fortesque	7	F	P	16
<i>Chrysophrys auratus</i> — snapper	2	P		3
<i>Cheilinus bimaculatus</i> — wrasse	1	P		1
<i>Cristiceps australis</i> — crested weedfish	2	P		2
<i>Enoplosus armatus</i> — oldwife	1	P		2
<i>Favonigobius lateralis</i> — long finned goby	2	P		2
<i>Favonigobius tamarensis</i> — tamar river goby	3	P	P	5
<i>Girella tricuspidata</i> — blackfish	9	C	F	ca. 100
<i>Gobiopterus semivestitus</i> — transparent goby	1	P		1
<i>Hippocampus abdominalis</i> — seahorse	1	P		1
<i>Hyporhamphus australis</i> — garfish	2	P		7
<i>Lethrinus nematacanthus</i> — scavenger	1	P		1
<i>Meuschenia freycineti</i> — leather jacket	2	F		33
<i>Meuschenia hippocrepsis</i> — variable leather jacket	2	P		2
<i>Meuschenia trachylepis</i> MER 105 E	4	P		5
<i>Monacanthus chinensis</i> — fan bellied leather jacket	1	P		1
<i>Mugil cephalus</i> — sea mullet	1	P		9
<i>Mugil georgii</i> — fantail mullet	1	P		1
<i>Mugilidae</i> (juveniles)	1	A		40
<i>Muraenichthys australis</i> — worm eel	1	P		1
<i>Myxus elongatus</i> — sand mullet	1	P		1
<i>Neodax balteatus</i> — little rock whiting	1	P		2
<i>Nesogobius pulchellus</i> — pretty goby	5	C		75
<i>Nesogobius</i> sp. MER 278 T — goby	2	P		5
<i>Ophisurus serpens</i> (juv.) — snake eel	2	P		2
<i>Parkraemia ornata</i> — ornate goby	3	P		3
<i>Penicipelter vittiger</i> — leather jacket	1	P		1
<i>Petroscirtes lupus</i> — blenny	2	P		2
<i>Platycephalus fuscus</i> — dusky flathead	3	C		51
<i>Platycephalus laevigatus</i> — smooth flathead	1	P		1
<i>Platycephalus marmoratus</i> — marbled flathead	1	P		2
<i>Pomatomus saltatrix</i> — tailor	2	P		5
<i>Pranesus ogilbyi</i> — hardyhead	1	P		2
<i>Pseudogobius olorum</i> — swan river goby	1		P	1 low salinity
<i>Redigobius macrostoma</i> — large mouthed goby	3	P	P	7
<i>Rhabdosargus sarba</i> — tarwhine	2	P		3
<i>Scorpaena</i> cf. <i>cruenta</i> — rock cod	1	P		4
<i>Sillago ciliata</i> — sand whiting	4	F		16
<i>Sillago maculata</i> — trumpeter whiting	1	P		4
<i>Stethojulis interrupta</i> — wrasse	1	P		12
<i>Stigmatophora argus</i> — spotted pipefish	5	A		95
<i>Stigmatophora nigra</i> — pipefish	4	A	P	206
<i>Syngnathus phillipi</i> — pipefish	6	P	P	9
<i>Torquigener glaber</i> — puffer	3	P	P	5

Scientific and common name	Number of records	Merimbula	Pambula	Total caught and Remarks
<i>Torquigener hamiltoni</i> — puffer	3	P		3
<i>Urocampus carinirostris</i> — pipefish	6	P	P	12
<i>Usacaranx georgianus</i> — trevally	6	A		213
<i>Vincentia chrysurus</i> — cardinal fish	1	P		2

TABLE 3. Aquatic birds recorded by David Milledge (pers. comm.) in Eurobodalla Shire estuaries in 1974-76. Species seen at Merimbula marked with an asterisk. Relative abundance shown by R = rare; O = occasional; F = frequent; C = common; dotted line means present at that level throughout year.

Scientific and common name	Winter	Spring	Summer	Autumn	Habits	Food
<i>Anas castanea</i> — chestnut teal	F.....				dabbler	invertebrates
<i>Anas gibberifrons</i> — grey teal	O.....				dabbler	invertebrates and algae
<i>Anas superciliosa</i> * — black duck	F.....				dabbler	invertebrates and algae
<i>Ardea novaehollandiae</i> * — white-faced heron	C.....				wader	fish and crustacea
<i>Arenaria interpres</i> — turnstone			R		wader on mud, sand and rocks	invertebrates
<i>Butorides striatus</i> — mangrove heron	F.....				wader in mangroves and on oyster racks	crustacea
<i>Calidris acuminata</i> — sharp tailed sandpiper			R		wader on sandy mud	invertebrates
<i>Calidris canutus</i> — knot		O	F		wader on sandy mud	invertebrates
<i>Calidris tenuirostris</i> — great knot			R		wader on sandy mud	invertebrates
<i>Calidris ferruginea</i> * — curlew sandpiper			R		wader on sandy mud	invertebrates
<i>Calidris ruficollis</i> — red-necked stint		O	O		wader on sandy mud	invertebrates
<i>Charadrius bicinctus</i> — double banded dotterel	F			F	wader on muddy sand	invertebrates
<i>Charadrius mongolus</i> — Mongolian dotterel			R		wader on muddy sand	invertebrates
<i>Charadrius ruficapillus</i> — red-capped dotterel	F.....				wader on muddy sand	invertebrates
<i>Cygnus atratus</i> * — black swan	C.....				swimmer	grazes on <i>Zostera</i> etc.
<i>Egretta alba</i> — white egret	F.....				wader	fish and crustacea
<i>Egretta garzetta</i> * — little egret	F.....				wader	fish and crustacea
<i>Egretta sacra</i> — reef heron	O.....				wader on rocky shores	fish and crustacea

DESCRIPTIVE NOTES ON FAUNA AND FLORA

Species and common name	Winter	Spring	Summer	Autumn	Habits	Food
<i>Haematopus fuliginosus</i> * — sooty oystercatcher		F			wader on rocks and oyster racks	invertebrates
<i>Haematopus longirostris</i> * — pied oystercatcher		C			wader on sandy mud	mainly crustacea
<i>Hydroprogne caspia</i> — caspian tern			R		plunge dives	fish
<i>Larus novaehollandiae</i> * — silver gull		C			scavenges on shores and shallows	general carnivore
<i>Limosa lapponica</i> * — bar-tailed godwit		C	C		wader on mud	mainly polychaetes
<i>Numenius madagascariensis</i> * — eastern curlew		C	C		wader on mud in mangroves	invertebrates
<i>Numenius phaeopus</i> — whimbrel		O	O		wader on mud, sand and stones	invertebrates
<i>Pelecanus conspicillatus</i> — Australian pelican			O		swimmer	fish
<i>Phalacrocorax carbo</i> * — black cormorant		C			swimmer and diver	fish
<i>Phalacrocorax melanoleucos</i> * — little pied cormorant		C			swimmer and diver	fish
<i>Phalacrocorax sulcirostris</i> * — little black cormorant		O			swimmer and diver	
<i>Platalea regia</i> — royal spoonbill		O			wader in shallows	invertebrates
<i>Pluvialis dominica</i> — eastern golden plover		R			wader on sandy mud	invertebrates
<i>Pluvialis squatarola</i> — grey plover		R			wader on sandy mud	invertebrates
<i>Podiceps poliocephalus</i> — hoary-headed grebe		R			swimmer	fish and weed
<i>Sterna albifrons</i> — little tern		O			plunge dives	fish
<i>Sterna bergii</i> * — crested tern		C			plunge dives	fish
<i>Sterna hirundo</i> — common tern			R		plunge dives and dips	fish
<i>Threskiornis aethiopica</i> — white ibis		O	R		wader on mud flats	invertebrates
<i>Tringa hypoleucos</i> — common sandpiper		O			wader on sandy mud and rock	invertebrates
<i>Tringa nebularia</i> — greenshank			R		wader on muddy sand	invertebrates
<i>Vanellus miles</i> — spur-winged plover		F			wader on rocks and mudflats	invertebrates

DISCUSSION

This survey of Merimbula Lake and the nearby estuaries provides some basic data on the animals and the plants occurring there. The resultant species list (Table 1) can be compared with other estuarine areas in New South Wales, although as mentioned in the Introduction, faunal and floral surveys of New South Wales

estuaries are few and even when they have been carried out, some taxonomic problems exist, for example polychaetes which were almost all identified to species at Merimbula have often not been identified elsewhere. Thus some caution must be taken in interpreting and comparing species lists. Many species occurring in estuaries are not consistently present and, unless regular sampling is carried out, will appear absent.

Recently Hutchings and Murray (in press) have described the polychaete fauna of New South Wales estuaries (over 180 species). They found that Merimbula shares some species in common with more northerly regions but some species have only been reported from Merimbula. Although the Australian Museum has extensive polychaete collections from New South Wales, many areas have been poorly collected especially the northern rivers and so it is premature to comment on the zoogeography of estuarine polychaetes in the state or along the east coast of Australia. Many more species, including many undescribed ones will probably be found to occur in the region. Similar problems arise with the crustaceans, and many of the dominant isopods and amphipods found at Merimbula have not been fully identified. The decapods collected from Merimbula share many species in common with Sydney areas (Hutchings and Recher, 1974). Molluscs are probably the best known group of estuarine invertebrates, and for this group an area just further south at Green Cape (Rudman, pers. comm.) represents an important transition zone between southern and northern faunas. Merimbula has a similar mollusc fauna to those areas further north in New South Wales.

In summary it is premature to compare in detail the estuarine fauna and flora of Merimbula with other estuarine areas of New South Wales, however some general comments can be made. Lake Merimbula has a rich and diverse estuarine fauna which shares many species in common with areas further north in New South Wales, but the fauna also has a southern component. However, detailed information on estuarine fauna further south is almost completely lacking except for the molluscs.

Although information on salinity and sediment was collected at Merimbula it was not collected systematically enough to correlate the fauna with these two physical parameters in any detailed way except perhaps on the three line transects carried out in Merimbula Lake which will be dealt with in a subsequent paper. However, in general polychaetes, one of the dominant infaunal groups do not necessarily show a good correlation with sediment type (Jones, in press) and although sediment must be important other factors such as salinity have an overriding effect. Some polychaetes however do show a specific sediment relationship in the Hawkesbury (Jones, pers. comm.). Collett *et al.* (in press) have analysed the infauna of *Posidonia* seagrass beds and have shown that the fauna in Top Lake is different from East Lake, presumably due to differences in salinity. The *Posidonia* fauna of East Lake showed more similarity with estuarine sites further north, than with the fauna of Top Lake, suggesting that latitudinal differences may be less important than salinity.

The polychaete fauna of Merimbula resembles many other estuarine areas in that a species may occur in a wide variety of estuarine habitats, including intertidal, subtidal, bare muddy substrates and seagrass beds (both *Posidonia* and *Zostera*). Although in Table 1, subtidal habitats are not classified, Hutchings and Recher (1974) gave lists of species which occur in both seagrass habitats, which appear to be very different physical habitat. Hutchings and Recher (1982) have postulated that in temperate areas, the mangrove fauna is basically the fauna of adjacent intertidal mud flats whereas in the sub-tropics and tropics a specialised mangrove fauna occurs which does not overlap with the fauna of adjacent mud flats. The mangrove fauna at Merimbula supports this hypothesis.

We believe that our study of Merimbula has provided a framework on which a more detailed study can be planned, and hypotheses generated and tested on the factors important in determining the distribution of estuarine animals. Only then can valid comparisons be made between similar estuaries; for along the New South Wales coast a wide variety of estuaries and lagoons occur which can be relatively easily characterised by their geomorphology, flushing patterns, fresh water inputs (Chapman *et al.*, 1982; Roy, 1982). Superimposed upon these physical characteristics are varying levels of man's impact on the estuary, which are difficult to determine, but which must be determined, if valid comparisons of estuarine fauna's and flora's are to be made. However it seems likely that although some broad generalisations can be made about similar physical estuaries, each estuary has its own unique characteristics.

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